

## GENERAL CHARACTERISTICS OF THE MOVEMENTS OF VANESSA CARDUI (L.)

J. W. TILDEN

*San Jose State College, San Jose, Calif.*

IT IS A MATTER of common knowledge that the populations of many species of butterflies participate in large and extensive mass movements. While several workers, notably C. B. Williams of England, have done extensive work in this field, relatively few investigators have made it their principal subject of research. Though much pertinent information has been assembled and certain tentative conclusions may be reached, it cannot be said that the movements of butterflies are as well understood as certain other phases of the study of these insects.

Most movements of butterflies, while usually referred to as migrations, would not meet the criteria set up by students of vertebrates for defining migrations. The migrations of birds, for example, involve cyclic movements. There is a going out and a return. Few butterflies other than the Monarch [*Danaus plexippus* (L.)], habitually possess such a rhythmic pattern of movement. Even with the Monarch, the individuals that return are usually (probably always) not the same individuals that initiated the outward movement, but are the offspring of these original individuals.

Many movements of butterflies are relatively local wanderings, and may be in one direction in one local area, but in a different direction in another area a relatively few miles away. For example, in the fall of 1960, Tilden noted *Libytheana bachmanii* (Kirt.) (the Snout Butterfly) moving southwesterly in large numbers in the vicinity of Continental, Pima Co., Ariz., on Sept. 14. The next day, Sept. 15, equally large numbers of this species were observed moving up-canyon (northward) in Sycamore Canyon, Santa Cruz Co., about thirty-five miles south of Continental by air line, though considerably further by road.

The very conspicuous movements of certain species have been regarded as depending on population pressures, leading to a mass exodus. These may be considered as emigrations from the populated area, and as immigrations into surrounding area. Such movements frequently appear to be in one direction only. Unless the insects were to find suitable conditions at the far end of the movement, establish-

ment would not result. Such movements have been thought to account in part for the finding of strays far beyond the normal ranges of the species.

Movements of an altitudinal nature have been observed. *Nymphalis californica* (Bdv.) has been seen ascending the Sierra Nevada of California in great numbers. Such movements may result in finding sufficient larval food plants for a subsequent brood. In 1960, Tilden found this species in outbreak numbers of adults at Manzanita Lake, Lassen Volcanic National Park, Calif., on June 10-17. Numerous larvae in various stages of development were found on *Ceanothus spp.* Adults could be observed many miles below the Park, working their way up the mountain. It may be significant to note that this species passes the winter as an adult. It seems plausible that these altitudinal movements of adults are the usual way for adults to reach the higher elevations, where they act as parents of a late high elevational brood. This might be a fruitful field of investigation.

The often spectacular "migrations" of *Vanessa cardui* (L.) present an interesting condition somewhat intermediate between true migrations and other types of movements. Return movements seem not to be clearly documented in regard to this species. However, reproduction has been observed repeatedly along the route, and the offspring take up the movement when they emerge as adults. These mass movements of *Vanessa cardui* thus proceed in periodic waves, alternating with relative lulls between, and the whole process has much more continuity than is characteristic of the movements of most other butterfly species.

Much of the basic work on the movements of *Vanessa cardui* has been done by C. H. Abbott. Others, including Sudgen, Woodbury and Gillette in Utah, have made contributions. Among the various titles that form the literature on the movements of this species in western United States, some are short observational notes only. Others present a considerable amount of detailed study. Abbott has attempted to understand the nature of these movements and has produced several penetrating papers on the subject.

The last great movement was in 1958. Abbott traces three or more generations extending up to or beyond the Central Valley of California. Other generations carried the waves through the Bay Region of California on into Oregon. The generations involved in the northern portions of the movement become less clear.

The first generation seems to have originated in northern Mexico, the second in the Imperial Valley of California, western Arizona and the eastern Mohave Desert of California, the third in western Mohave Desert, and the fourth in the Central and Coastal Valleys of California, and to the Bay Region. Abbott (1959) has presented material that includes the observations of a number of workers, and has coordinated this material. In addition, the following observations are here presented for the first time.

Tilden found many dead adults in western Arizona (Mohave County) and in the vicinity of Needles, California, as well as large numbers of moving adults, March 30-31, 1958. From Barstow, San Bernardino Co., west to Mohave, Kern Co., great numbers of adults were flying northwesterly on March 31. Later that day adults were seen moving through Tehachapi Pass, Kern Co., and spilling into the San Joaquin Valley east of Bakersfield, Kern Co. On April 20 to May 9, eggs and larvae were abundant in the Salinas Valley, Monterey Co.

On May 30 - June 1, Tilden found large numbers of adults along the Redwood Highway (Route 101) between San Rafael, Marin County, and Cloverdale, Sonoma County, moving northwesterly. Dead adults were seen as far west as Booneville, Mendocino County, where but a few living adults remained. This may mark the western edge of the movement.

In the vicinity of The Geysers, Sonoma County, adults were moving northwesterly in large numbers in overcast weather (fog) on June 1, before noon. Larvae were abundant on *Amsinckia* (Fiddleneck) and on the introduced Spanish Thistle (*Carduus*), in various stages of development.

Two interesting reports were from Oregon. Ray Albright reported large numbers of *Vanessa cardui* moving in a north-north-easterly direction on May 18-19, 1958, while on May 20-21, equally large numbers were observed moving in exactly the opposite direction. He attributes this reversal of direction to the insects meeting a cold front, since a storm was in progress some distance beyond the place toward which the insects were noted to be flying. The other report was from David Huntzinger at Crater Lake National Park. He noted that *Vanessa cardui* was abundant there in 1958, though scarce or absent in 1957.

On April 1, 1958, Tilden observed what is apparently a new observation for the United States. Large numbers of *Vanessa cardui* were flying north-westerly in the rain. Between Vidal, San Bernardino County, and Desert Center, Riverside County, the rain was light to moderate, but rather cold. Between Indio and Whitewater Canyon, later the same day, the flight still continued in heavy to very heavy rainfall. This seems to indicate that adults may continue to fly, once on the wing, even in heavy precipitation. It would seem *a priori* that initiation of a flight during rain might be less likely.

From observations so far recorded it is possible to generalize on some of the characteristics of the movements of *Vanessa cardui*. Some of these generalizations have been set forth by Abbott and others, while some are suggested here for the first time.

1. The adults tend to fly into the wind. This may be a key point in attempting to explain the prevailing direction of the movements. During the time of year when *Vanessa cardui* is moving, the prevailing winds in California are north-westerly, and the movements of the



butterflies are also in a north-westerly direction, almost or quite directly into the prevailing winds. Sudgen, in 1937, noted a northerly direction of flight in Utah. Sudgen, Woodbury and Gillette, in 1947, noted a north-easterly direction of flight. Observations to be made in the future might very well take special note of the wind direction as well as the direction of the insects' flight, to find how complete this correlation between wind direction and flight direction may be.

2. The adults move at a rather equal velocity in relation to one another, resulting in a fairly constant spacing of the individuals. There have been some observations made where this did not seem to be the case, but for the most part, this generality seems to hold.

3. The insects tend to fly over obstacles rather than around them. At times this appears to the observer quite amusing, even ridiculous. If a tree, building or parked car obstructs the route, the adults fly over the top of the obstruction, when in some instances it would appear that a veering to the right or left would be more easily accomplished. The obstruction, whether it be low or tall, is barely cleared. On March 30, 1958, Tilden observed them piling directly over a small building near Barstow, San Bernardino County, the only building for miles in an open desert.

4. The adults tend to fly at rather even densities. If a line is marked off between two points, fifty or one hundred feet apart, and the insects crossing this line per minute are counted, the results from several one minute counts are surprisingly similar. If then the observer drives his car several miles, sets up another station and makes another series of counts, the results will again be similar, and frequently quite close to those of the previous station. But in widely separated areas, the count may be very different. That is, while the density on the Mohave Desert, for instance, may be quite constant, counts made in San Diego County at another time might indicate a different density. Further study may shed light on the possibility that density of flight is related to density of population.

5. *Vanessa cardui* adults will fly in overcast, at least after the movement is under way. This has been observed between Victorville and Needles, San Bernardino County, March 31, 1958, and near The Geysers, Sonoma County, May 31 and June 1, 1958.

6. They have been observed once at least in the United States (*vide supra*) to fly in large numbers during moderate to very heavy rainfall.

7. The migrating individuals are all of one species. Other species of butterflies do not seem to become involved in the mass movements of *Vanessa cardui*.

8. The individuals in the flights are of both sexes. This was noted independently by sampling in 1958, by both Tilden and O. E. Sette. The sex ratio of the insects when engaged in a flight is very nearly the same as that of *Vanessa cardui* at any other time, 0.5 or one half

of each sex. Tilden took a sample of fifty adults, and found twenty-seven males, twenty-three females. The numbers taken by Sette are not recorded. This phase of the investigation deserves further study and this is planned for the future.

9. The females from the above sample were not greatly gravid. None had eggs ready to oviposit. This suggests that the females may drop out of the flight when ready to oviposit. If this be true, it might explain the tendency to reproduce along the flight routes.

10. The total movement proceeds in waves, or phases, which so far appear to be based on broods, a conclusion which seems to be well supported by the work of Abbott.

In the light of current findings, it is possible to reconstruct, at least to some degree, the nature of the populations of *Vanessa cardui* during and prior to the flights.

1. The first (initiating) brood apparently originates to the south, in northern Mexico or southwestern Arizona.

2. Findings from those movements that have been studied indicate that large flights can occur only in years when there has been sufficient rainfall on the deserts for a large growth of vegetation, enough to support such populations of *Vanessa cardui*.

3. The food plants in the desert areas, as noted by many observers, are principally Boraginaceae, especially *Cryptantha*, but also *Amsinckia*. Malvaceae have also been reported. Thistles and other composites seem to be of little importance at this time.

4. Upon emergence of the adults, each succeeding brood begins to fly into the wind, which in the deserts of California at this season (early spring) results in a north-westerly direction of flight.

5. These adults reproduce at some point along the line of flight. Time and place of reproduction presumably depend on the condition of the insects and the presence of suitable vegetation. Information on how far the females fly before reproducing, and the precise reason for selecting a certain place for reproduction, would add much to our knowledge.

6. Four to five broods, perhaps more, succeed one another before the force of the movement is spent.

7. The northern extent of the movement is at least to the San Francisco Bay Region of California. In some years, such as 1958, the effect extends into northern California, and apparently further, to Oregon and perhaps even Washington. Information as to the relationship between the *Vanessa cardui* in California and those in Oregon and Washington during such outbreak years is badly needed.

Williams and Abbott have raised the question as to whether *Vanessa cardui* is found north of the Imperial Valley, Imperial County, Calif., in any but outbreak years. There seems to be good evidence that it is. An examination of pinned specimens from many parts of California shows specimens taken in almost every year for many years

back. As a Professor at San Jose State College, Tilden has examined hundreds of student collections over a period of fourteen years, and has also examined other specimens dating back to 1920. Some specimens of *Vanessa cardui* appear in student collections every semester. It is evident that this species is a normal component of the butterfly fauna in many parts of California. It is probable, however, that this local endemic population has little or nothing to do with the mass movements which from time to time are superimposed on it.

Two other items seem worth mentioning. Firstly, moderate to large populations of *Vanessa cardui* may be found late in the fall at high elevations in the mountains of the western United States. Specifically, Tilden found hundreds of adults at Hannagan's Meadows, White Mountains, Arizona, September 12, 1960. A fair population was found at Barton Flats, San Bernardino County, Calif., in September, 1957. Similar populations have been reported from the Sierra Nevada of California and elsewhere. The nature of these populations is not known, but it would seem that they are independent of the populations concerned with the great flights that occur in certain years.

Secondly, the mass flights of *Vanessa cardui* are of a very irregular nature. They are not regularly cyclic and do not occur at predictable intervals. However, some success in predicting these flights has been possible through knowledge of rainfall on the desert. Several workers foresaw the 1958 outbreak in the gathering populations of the southwest deserts.

An interesting and provocative suggestion of how rainfall may be necessary for mass movements of this species, was observed by Tilden September 11, 1960, at Yucca, Mohave County, Arizona. Late summer rains were plentiful and vegetation was well developed. Numerous freshly emerged adults of *Vanessa cardui* were present, and reproduction was in progress, with larvae of various stages on *Cryptantha*. It seemed that the basis for a movement was all prepared. However, the winter rains did not materialize, and on March 26, 1961, the area around Yucca was dry and no *Vanessa cardui* were to be found. If this abortive season is contrasted with the abundant rainfall of 1958 over the entire area, it points to a dependence of these populations on ample winter rainfall in the areas that are far enough south to act as reservoirs for populations that can engage in a mass flight.

Several questions are raised: (1) Why do these insects move at all, rather than remaining where they are? Possibly food may become scarce, but populations exist that do not move out in such a systematic manner under lowered food conditions. (2) Why is the flight directed? Why do not these insects move randomly in any direction open to them? The tendency to fly into the wind may be a clue here. Or have such movements been repeated so many times over the history of the species, that the tendency to fly in one direction has been selected for? (3) What causes the adults to reproduce here and there along the

route? Why do they not merely fly on until exhausted? Present information may suggest some tentative answers, but such answers, while plausible, are not yet supported by sufficient data.

The author would add that this attempt at a synthesis of our knowledge concerning the movements of *Vanessa cardui* in western United States is prompted more by interest on his own part than by a desire to inform others. The purpose of this paper is to bring into focus our ignorance of the real basis of this interesting phenomenon, with a hope that future work will help to clarify some of the little known facets of the problem.

### LITERATURE CITED

- ABBOTT, C. H. 1941. The 1941 migration of the painted lady butterfly, (*Vanessa cardui*) in southern California. *Bull. Ecol. Soc. Amer.*, 22:13.
- 1946. Mapping the 1945 migration of *Vanessa cardui* in southern California. *Bull. Ecol. Soc. Amer.* 27:49.
- 1950. Twenty-five years of migration of the painted lady butterfly, *Vanessa cardui*, in southern California. *Pan-Pac. Ent.*, 26:616-172.
- 1951. A quantitative study of the migrations of the painted lady butterfly, *Vanessa cardui* L. *Ecol.* 32:155-171.
- 1959. The 1958 migration of the Painted Lady Butterfly, *Vanessa cardui* (Linnaeus), in California. *Pan-Pac. Ent.*, 35:83-84.
- ESSIG, O. E. 1926. A butterfly migration. *Pan-Pac. Ent.*, 2:211-212.
- SMITH, RAY F., & E. GORTON LINSLEY. 1945. Migration of *Vanessa cardui* (Linn.). *Pan-Pac. Ent.*, 21:109.
- SUGDEN, JOHN W. 1937. Notes on the migrational flights of *Vanessa cardui* in Utah. *Pan-Pac. Ent.*, 13:109-110.
- SUGDEN, JOHN W., ANGUS M. WOODBURY & CLYDE GILLETTE. 1947. Notes on the migration of the painted lady butterfly in 1945. *Pan-Pac. Ent.*, 23:79-83.
- WILLIAMS, C. B. 1958. *Insect Migration*. xiii +235 pp., 11 plates, 22 photos, 49 maps & diagrams. Collins, London.
- WOODBURY, ANGUS M., JOHN W. SUGDEN & CLYDE GILLETTE, 1941. Notes on migrations of the painted lady butterfly in 1941. *Pan-Pac. Ent.*, 18:165-176.